DOCUMENT RESUME

ED 076 430 SE 016 115

AUTHOR	Schafer, Larry E.
TITLE	The Effectiveness of Cue Fading in Teaching Kindergarten Children to Serial Order.
PUB DATE	Mar 73
NOTE	27p.; Paper presented at the annual meeting of the National Association for Research in Science Teaching (46th, Detroit, Michigan, March 1973)
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Cognitive Development; *Elementary School Mathematics; Instruction; Learning; *Learning Theories; Mathematics Education; Relationship; *Research
IDENTIFIERS	Research Reports

ABSTRACT

Fifteen kindergarten children, who began the study with Piaget's stage II seriation capabilities (they could serial order sticks but could not insert a number of sticks into an already ordered set), were individually given 30 minutes of seriation training on three consecutive days. Cue fading and the manipulation of discrimination levels were used in the training to help the children meet successive performance criteria leading to the acquisition of stage III criteria of both ordering sets and inserting objects into an already-ordered set. Posttests, each consisting of a near and far transfer measure, were given approximately 1, 8, and 132 days after training. Results showed that subjects acquired and retained the specific target capabilities of the training, but failed to transfer substantially those acquired capabilities to the performance of seriation tasks involving unfamiliar materials. (Author/DT)

THE EFFECTIVENESS OF CUE FADING IN TEACHING KINDERGARTEN CHILDREN TO SERIAL ORDER

By

Larry E. Schafer
Assistant Professor of Science Teaching
Department of Science Teaching
Syracuse University

Presented at the 46th Annual Meeting
of the
National Association for Research in Science Teaching
March 27-29, 1973
Detroit, Michigan

INTRODUCTION

To the young child, serial ordering is the operation of arranging objects side-by-side so that a particular characteristic of the objects increases in one direction. For example, sticks of various lengths may be ordered from the shortest stick to the longest to make a stairsteps-like figure.

Piaget's research (1965) and its replication by Elkind (1964) have revealed three stages in the development of serial ordering. In the first stage, the child (age 4) makes pairwise discriminations but fails to serial order four or more objects. In the second stage, the child (age 5) orders objects by trial and error but fails to correctly insert a disarranged set of objects into an ordered set. In the third and final stage, the child (age 6 or 7) both orders with ease and correctly inserts a disarranged set of objects into an ordered set. The primary purpose of this study was to investigate the effectiveness of one method (cuing and cue fading) of helping children in the second stage acquire the third stage capability of inserting objects into an ordered set.

Why instruct children to serial order when they acquire that ability without formal instruction? Piaget contends (Kohlberg, 1968) that the role played in cognitive development by massive, general types of experiences cannot, in general, be replaced by limited specific training. Studies of the effectiveness of inducing Piagetian conservation capabilities (e.g., Gelman, 1969; Kingsley and Hall, 1967; Goldschmidt, 1968; and Wallach, Wall, and Anderson, 1967) have cast doubt on Piaget's contention. Examination of the effectiveness of limited, specific instruction on the development of serial ordering has been minimal. Coxford (1964) found that serial and ordinal correspondence could be induced. He, however, failed to examine the transfer and retention of the induced capabilities. The study reported here extends the test of Piaget's contention further into the realm of serial ordering by examining the effects of instruction on the acquisition, retention, and transfer of the ability to insert objects into ordered sets.

Different training techniques have been used in various studies to obtain information on the way conservation capabilities are acquired "naturally." The assumption underlying these studies is that the more a training technique influences the developmant of a capability, the more that technique and its associated theory are likely related to the process by which the capability is acquired "naturally." By applying that assumption to serial ordering, the effectiveness of the instructional procedures used in this study, being based on the idea that children acquire the ability to serial order by learning to attend to the relevant task characteristics, will likely indicate whether or not attention factors play a role in the "natural" development of serial ordering.

Serial ordering is a fundamental capability that underlies many intellectual functions. It is necessarily involved in comprehending the concept of number (Piaget, 1965, p. 184). It likely plays a significant role in the acquisition and use of language skills since words, sentences, and paragraphs must be sequenced in particular ways before communication occurs. With regard to elementary school science, serial ordering is used in logical operations (if... then...) and in time-space and cause-effect relationships. Furthermore, the young scientist may use it to discover relationships. For example, just as Mendeleef serial ordered chemical elements according to atomic weights and observed the periodic reocurrence of similar physical and chemical properties, the young scientist could order plants according to some treatment variable (e.g., total time exposed to light) and then more easily discover how particular plant characteristics relate to that treatment variable.

With serial ordering being inherently involved in a number of intellectual functions, changes in the ability to order might yield changes in those intellectual functions. According to the findings of Bloom (1964), a capability is most susceptible to change while it is developing. Perhaps then, through appropriate instruction given during the development of serial ordering a significant impact might be made not only on the ability to order but also on the manifestation of that ability in those intellectual functions which

depend on the facility to deal with order. The study reported here is an examination of one way of inducing change during the development of serial ordering. It sets the stage for the studies that will be designed to examine the effects of such a change on those intellectual functions in which order is a significant factor.

PROCEDURES

The sequence of experimental events occurred as follows. A serial ordering pretest was given to all of the 95 children attending kindergarten in the small, rural community of DeWitt, Michigan. After the children had been assigned to the three serial ordering stages on the basis of their pretest performances, those children in stage II were randomly divided into a control group (n=17) and an experimental group (n=15, an attrition of two because of illness). The experimental subjects were then given approximately thirty minutes of instruction on each of three consecutive days. The control subjects were given no instruction. Serial ordering posttests, each consisting of near and far transfer measures with the third posttest including, in addition, a far-far transfer measure, were administered to all experimental and control group subjects approximately one, seven, and 132 days after instruction. A special control group, comprised of children who were in stage III at the beginning of the experiment, was also given the third posttest.

Pretest Procedures and Materials

Sticks, three-fourths inch square in cross section and varying in length from one and one-half to nine inches, were used in the serial ordering pretest. The pretest consisted of six tasks. Three tasks challenged the child to serial order a set of sticks from the shortest to the tallest. Each of the other tasks challenged him to correctly insert a set of three disarranged sticks into an ordered set. The tasks were presented as follows: four sticks were to be ordered and then three inserted into that ordered set, six ordered and three inserted, and finally eight ordered and three inserted. The length of the sticks in each ordered set increased

by one inch increments beginning with a two inch stick. To help the child understand what kind of responses were expected during the pretest, the experimenter provided examples of how to perform the ordering and inserting tasks.

The children were assigned to the serial ordering stages according to the following criteria. Children who correctly performed at least two of the ordering tasks and no more than one of the insertion tasks were assigned to stage II. Those children who correctly performed all of the ordering tasks and at least two of the insertion tasks were assigned to stage III. All other children were assigned to stage I.

Instructional Procedures and Materials

Gelman (1969) has produced empirical support for the contention that children fail to perform Piagetian conservation tasks not because they lack certain cognitive capabilities (e.g., reversibility) but because they do not attend to the relevant task characteristics. Perhaps the inability to perform serial ordering tasks likewise stems from the child's failure to attend to the relevant task characteristics and operations. Considering this to be the case, the instructional procedures used in this study were designed to give the children the opportunity to learn which of the task characteristics and operations were relevant. It was assumed that the opportunity for learning about the relevant characteristics and operations would be the greatest during the successful performances of the instructional tasks. Therefore, to insure a high incidence of success throughout the instruction, the tasks were sequenced from the least difficult (few objects, no fine discriminations) to the most difficult (many objects, fine discriminations), and cues were used and faded as the children gradually acquired the ability to correctly insert objects into ordered sets.

The first instructional session. For the first of the three instructional sessions, forty-five instructional stations were used and each station was supplied with a set of sticks like those used in

the pretest.

Every experimental subject was individually guided by the experimenter from one station to the next. At each station, a disarranged set of sticks and two ordered sticks appeared before the subject. Only one of the sticks in the disarranged set would fit between the two ordered sticks to make a serial ordered set of three. The subject's task was to find that one stick and place it between the two ordered sticks.

The forty-five stations consisted of three groups of fifteen stations. The three groups of fifteen stations differed with respect to the number of sticks in the disarranged sets of sticks. The first fifteen stations had two sticks in the disarranged sets, the second fifteen stations had three sticks in the disarranged sets, and the third fifteen stations had four sticks in the disarranged sets.

Each group of fifteen stations consisted of five subgroups of three stations each. The five subgroups within each group of fifteen stations differed with respect to the fineness of discriminations required in task performance. In other words, each subgroup corresponded to a discrimination level; hence, the three stations within each subgroup provided practice at one discrimination level.

In the progression from one subgroup to the next, finer and finer discriminations had to be made. This was true only for progression within one of the three large groups. Progression from one large group to the next resulted in an abrupt drop in discrimination level since all of the large groups started with approximately the same low discrimination level.

The second instructional session. For the second instructional session, thirty instructional stations were used and each station was supplied with a set of sticks. At each of the first fifteen stations, four of six sticks appeared already serial ordered along a line to make stairsteps, and the remaining two appeared disarranged below the ordered set. At each of the second fifteen stations, six of nine sticks appeared ordered and the remaining three appeared disarranged.

The nature of the task was the same at all thirty training

stations. The child was instructed to insert the disarranged sticks into the serial ordered set so that all of the sticks were used in making stairs. The tasks presented at the first fifteen stations required that two sticks be correctly inserted into a set of four sticks. The task for the second group of fifteen stations required that three sticks be correctly inserted into a set of six sticks.

For each of the two groups of fifteen stations, relatively strong cues were given in the beginning stations and then these cues were faded in five steps as movement through the fifteen stations progressed. Within each large group of fifteen stations there were five subgroups of three stations each, and each of these five subgroups corresponded to a cue level. All three stations comprising a subgroup provided practice at one particular cue level.

The cues appeared in the ordered set of sticks. The cues were designed to aid the child in finding the positions in the set where insertions would take place. Although the cues had the potential for helping the child locate the positions for insertion, they could not have helped the child choose the correct stick for those positions.

An ordered set of sticks which contained cues looked as if some of the sticks were missing. In other words, the lengths of sticks increased in regular increments except for those places where insertion would take place. At those places where a stick would be inserted, the increment was comparatively large (see Figure 1).

In the progression from one cue level to the next, the large increments used in cueing were gradually reduced to regular increments in five stages. The last set of materials in each of the two groups of fifteen stations offered no cues at all. In those ordered sets containing no cues, the lengths of the sticks increased in regular increments and the regular increment was the same as the regular increment in the ordered sets containing cues. Figure 1 shows examples of ordered sets from each of the five cue levels.

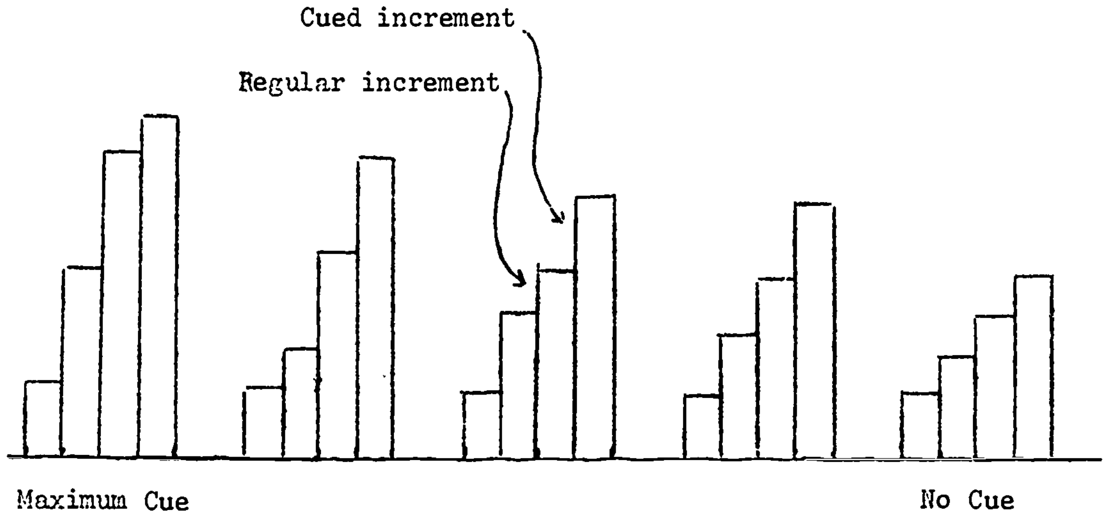


Fig. 1. Examples of ordered sets from each of the five cue levels.

<u>The third instructional session</u>. During the first two instructional sessions, sticks were used. To help the subjects generalize the process of serial ordering, a new material was used in the third instructional session.

The materials consisted of rectangular pieces of posterboard upon which were cemented photographs of parallel, evenly spaced, black lines. These cards measured one and three-quarters by four and one-half inches, and the lines on them were parallel to the short side. There were twelve different numbers of lines used on the cards. These numbers ranged from three to thirty-two in such a way that if X were the ordinal position of a card (the card with the Xth most lines), then Y, the number of lines, could be calculated from the following formula: $Y \doteq e^X$.

In the various training trials the subject was presented with two sets of lined cards. One set was serial ordered with respect to the number of lines on the cards, and the other set was disarranged. The task was to correctly insert the disarranged cards into the serial ordered set.

As in the second instructional session, cues were used to aid the subjects in making the correct responses. Twice the cues were

introduced and faded in the instructional sequence of twenty-four stations. Strong cues were used at the beginning of the sequence and these were faded in four stages until no cues were used for those trials appearing in the middle of the sequence. Just after the cues had been faded for the first half of the sequence, more cards were introduced into the tasks. To help the student overcome the added difficulty of having to deal with more cards, the cues were introduced again and then faded in four stages until the last three trials contained no cues.

The width of the lines served as the cue. For those sets of cards in which the cues were present, the number of lines on a card and the width of lines were directly related.

As mentioned above, the cues were faded in four stages. The variation in line widths of a strongly cued set of cards was comparatively large. In the progression from one cue level to the next, the variance in line widths was reduced toward a mean line width. The sets of cards in which no cues were used had no variation in line width.

Instructional feedback and performance criteria. During all three instructional sessions, the children were given both verbal (very good, nice job, correct) and material (marbles) reinforcers for correct task performances. Whenever an error was made, the children were shown the correct way to perform the task and were then recycled through the discrimination or cue level in which the error occurred until a minimum performance criterion was met.

Posttest Procedures and Materials

Posttests were given to all experimental and control group subjects approximately one, seven, and 132 days after instruction. The first two posttests were exactly alike and were comprised of near and far transfer measures. The third posttest, somewhat different from the first two, was comprised of near, far, and far-far transfer measures.

Materials and tasks for posttests one and two. The four different

kinds of materials used in each of the first two posttests were: sticks, lined cards, wooden "cars," and blue painted blocks. Both ordering and inserting tasks were performed with all of the materials except sticks. Only inserting tasks were performed with sticks, since all subjects in the study had demonstrated the ability to order sticks on the pretest.

All of the training was focused on the insertion capability. Consequently, there existed the possibility that the training would be very specific and would result in the subjects being able to insert but not being able to order. Since stage III performance with any set of materials requires both serial ordering and inserting, the posttest included both serial ordering and insertion tasks for all materials except sticks.

The testing materials were set up at stations and the subjects were guided individually from one station to the next in the testing sequence. The materials were presented in the following order: sticks, lined cards, "cars" and colored blocks. Whenever both ordering and inserting tasks were performed with a given material, the ordering task always preceded the corresponding inserting task. The tasks and materials are described below in the order in which they were presented during the posttest. Since the materials and tasks were the same in the first two posttests, the description applies to either of those posttests.

Sticks like those used in the training were used to test the child's ability to insert a set of disarranged sticks into a serial ordered set. Three different trials were presented and the number of sticks in both the disarranged set and the ordered set were increased from one trial to the next. In the first trial, two sticks were to be inserted into a serial ordered set of four; in the second trial, three were to be inserted into six; and in the final trial, four sticks were to be inserted into a serial ordered set of eight.

Lined cards, like those used in the training, were used in a second series of trials. The first task required that four lined cards be serial ordered from the card with the fewest lines all the way to the card with the most black lines. The second task required

that two additional lined cards be inserted into the four cards just serial ordered. The ordering and inserting sequence was repeated again with six cards to be ordered and three to be inserted into the ordered six.

Wooden "cars were used in the next trials. A wooden "car" was a stick with short dowels glued to one side to give the impression of wheels. The "cars" looked like boxcars of a train and were serial ordered with respect to length Rather than order the "cars" side-by-side to form a staircase-like figure, the "cars" had to be ordered from end-to-end along a track to form a "train."

There was one ordering and one insertion task performed with "cars." Six "cars" were presented disarranged and the subject was instructed to order them from the shortest to the longest along a track drawn on a sheet of paper. If the subject could not order the cars, the tester arranged the cars in serial order for the insertion task which followed. Once an ordered set of cars had been formed, either by the subject or the tester, the subject was given three additional "cars" to insert into the ordered set of six.

Colored blocks were used in the last two trials of the test. A block was constructed of wood three-quarters inch wide, three-quarters inch thick, and four inches long. A piece of posterboard was cemented to one side of each block, and each piece of posterboard was painted a different shade of blue.

In the first test trial with colored blocks, the subject was instructed to place eight blocks side-by-side in serial order from the lightest to the darkest blue. If the child failed to order the eight colored blocks, the tester ordered the blocks for use with the insertion task which followed. In the final task, the subject was presented with three disarranged colored blocks and the serial ordered set from the previous trial. The subjects were instructed to insert the three disarranged blocks into the ordered set so that all blocks would be arranged from the lightest to the darkest blue.

The test trials in which sticks and lined cards were used were considered near transfer trials because the materials used in the trials

were the same as those used in the training. Since the "cars" and colored blocks were not used in training and since the results of a previous study (Schafer, 1969) suggest that these materials were somewhat more difficult to order and insert than sticks, the trials with "cars" and colored blocks were considered far transfer trials.

The near transfer score for each subject on each posttest consisted of the per cent of near transfer tasks performed without error. Likewise, the far transfer score consisted of the per cent of far transfer tasks performed without error.

Materials and tasks for posttest three. The third posttest consisted of near, far, and far-far transfer tasks. There were two near transfer tasks, and in each, a disarranged set of sticks was to be inserted into an ordered set. In the first near transfer task, five sticks were to be inserted into an ordered set of 10. In the second near transfer task, six sticks were to be inserted into an ordered set of 12.

There were two far transfer tasks, each of which required that a disarranged set of "cars" be inserted into an ordered set of "cars." In the first task three "cars" were inserted into an ordered set of six, and in the second task, four "cars" were inserted into an ordered set of eight.

"Happies" and storycards were the two different materials used in the far-far transfer tasks of the third posttest. The tasks performed with "happies" and story cards were considered measures of distant (far-far) transfer since evidence from a pilot study revealed that first grade children found the tasks somewhat challenging.

"Happies" were rectangular pieces of white posterboard on which were drawn smiling faces. The faces were used only to give each card a particular orientation so that height and girth of the card could be determined. The "happies" were ordered according to girth or "fatness" (i.e., the width of the card). The height of the "happies" varied randomly with respect to the girth; hence, height was considered an irrelevant dimension.

Two specific tasks were performed with the "happies." After a

brief orientation session in which the subjects were taught both to distinguish between fat and skinny "happies" and to disregard the height of the "happies," the subjects were given six "happies" which they were to order side-by-side from skinniest to fattest. If the task was not performed correctly, the tester arranged the six "happies" in the proper serial order for use in the next task. The second task with "happies" challenged the subjects to insert two additional "happies" into the ordered set of six.

Storycards were used in the last two tasks of the far-far transfer measures. The storycards were rectangular pieces of poster-board, each showing a picture of a stick man, the ground, a diving board, and water. The picture on each card showed the man at a different stage in the process of climbing up the diving board and diving into the water.

To perform the first task with storycards, the subject had to put nine storycards in order showing the sequence of the stick man climbing the ladder and diving into the water. Each subject was given the first card in the sequence. Before going onto the second task with the storycards, the tester made sure that all cards were in the proper order. With the correct sequence of cards present, the subject's second task with cards was to correctly insert two additional cards into the ordered set.

Instructions given during posttests. To help standardize the administration of the posttests, the same verbal instructions were given to each subject. The general format of instructions used with each material was the same. First, an orientation session was presented to make sure the subject understood the nature of the task. Next the subject was instructed to order or insert according to a specified attribute. Each time a subject finished a task he was asked to recheck his work and correct any mistrakes which may have been made. No feedback was given to the subjects during the posttesting.

RESULTS

Since the third posttest, unlike the first two, contained a far-far transfer measure and since the special control group (subjects who performed at stage III on the pretest) received only the third posttest, not all levels of the design were completely crossed with all other levels. Therefore, the analysis of the data was performed in two parts.

The Experimental versus Control Group Analysis

The data considered in this part of the analysis consisted of the experimental and control subjects' near and far transfer scores from each of the three posttests. Each score was the per cent of seriation tasks performed without error. The group means (mean per cents correct) and standard deviations calculated from the near and far transfer scores appear in Tables 1 (near transfer) and 2 (far transfer). Graphic displays of the group means appear in Figure 2.

Table 1

Near Transfer Means and Standard Deviations
(Percentages)

	Experimental		Control		Overall	
	Mean	SD	Mean	SD	Mean	SD
Posttest 1	83.9%	18.7%	38.7%	24.4%	59.9%	31.9%
Posttest 2	80.0	22.6	52.4	21.4	65.3	26.4
Posttest 3	76.7	40.3	52.9	43.6	64.1	44.4
Overall	80.2	28.9	48.0	32.1		

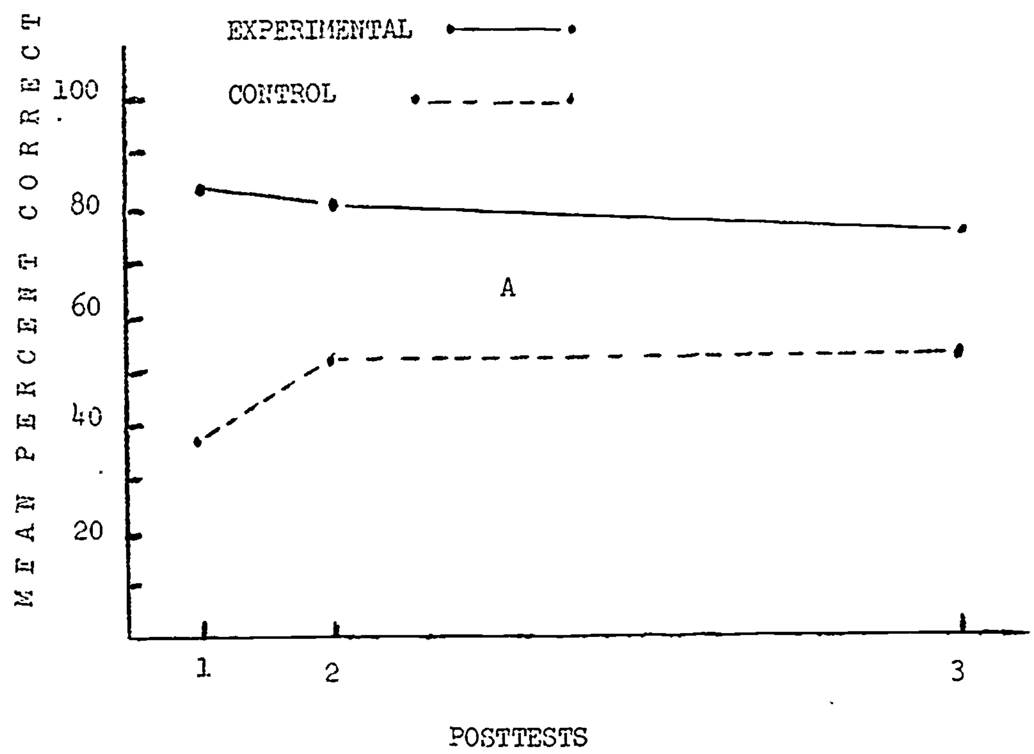
Table 2

Far Transfer Means and Standard Deviations
(Percentages)

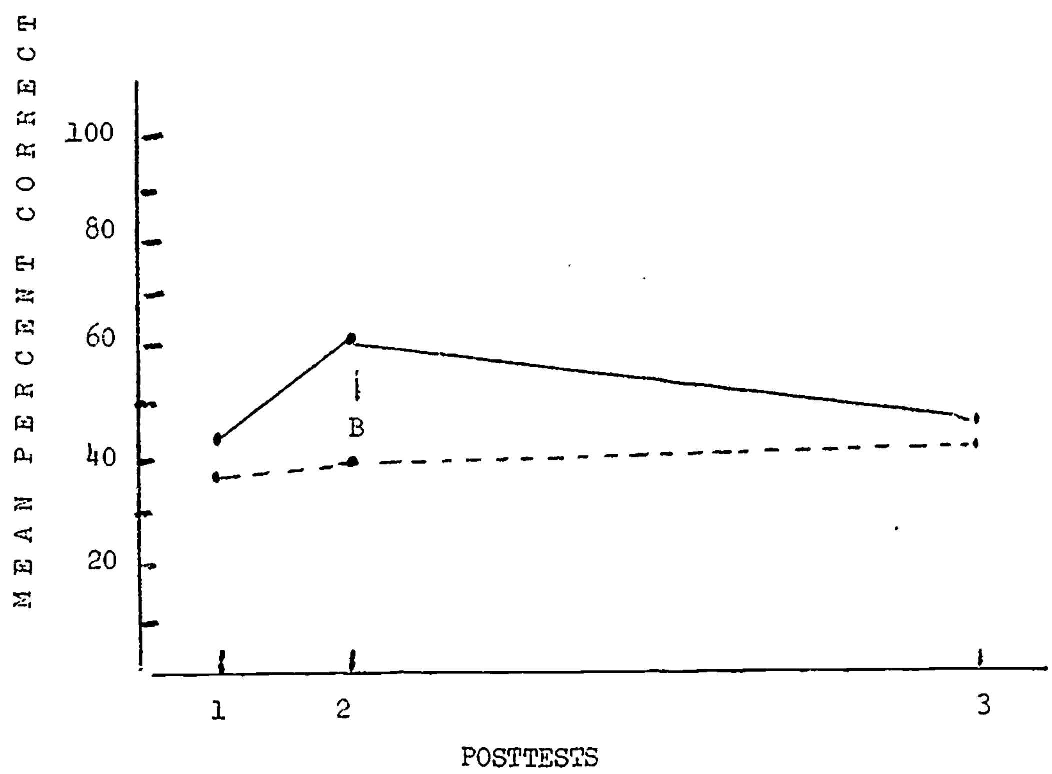
	Experimental		Control		Overall	
	Mean	SD	Mean	SD	Mean	SD
Posttest 1	41.7%	19.7%	35.3%	22.8%	38.3%	21.9%
Posttest 2	68.3	33.5	39.7	24.3	53.1	32.8
Posttest 3	46.7	42.7	41.2	30.8	43.8	37.6
Overall	52.2	35.3	38.7	26.3		

Fig. 2. Graphs of the experimental and control groups near and far transfer means. The distances from the absissa to the posttest numbers were scaled according to the function $N' = .5 \sqrt{N}$, where N' was the number scaled and N was the number of days between the end of training and the particular posttest. The posttests were given approximately 1, 8, and 132 days after training.

NEAR TRANSFER MEANS



FAR TRANSFER MEANS



Since the experimental and control groups (treatment factor) were repeatedly measured (posttests 1,2, and 3 - posttest factor) on multiple variables (near and for transfer measures - test type factor), a repeated measure, multivariate analysis of variance (Bock, 1963) was used to statistically analyze the data. The results of that analysis are summarized in Table 3.

Table 3

The Results of the Repeated Measures, Multivariate Analysis of Variance: Experimental versus Control Group Analysis

Source	df	Multivariate F	p less than
Treatment (T)	1,3	8.1623	0.0077
Posttest (P)			
Part 1*	1,30	4.4951	0.0424
Part 2	1,30	14.0421	0.0008
Test Type (t)	1,30	16.1776	0.0004
T X P			
Part 1	1,30	0.3963	0.5338
Part 2	1,30	2.0586	0.1621
T X t	1,30	6.0730	0.0202
P X t			
Part 1	1,30	0.3834	0.5410
Part 2	1,30	0.0964	0.7588
T X P X t			
Part 1	1,30	5.7668	0.0235
Part 2	1,30	3.2314	0.0839

*According to the method of analyses used, there were two parts to the test of any source of variation in which the posttest factor (three levels) occurred. If either part of the test was significant, the corresponding source of variation was considered significant.[1]

With the probability of falsely rejecting a true null hypothesis chosen to be 0.05, Table 3 reveals significant Treatment, Posttest, and Test Type main effects, and significant Treatment X Test Type and Treatment X Posttest X Test Type interactions.

[1]Dr. William Schmidt, Educational Psychology, Michigan State University personal communication.

Whereas a two-way interaction is determined by the degree to which the "shapes" of two lines correspond, a three-way interaction is determined by the degree to which the "shapes" of two surfaces correspond. The two surfaces labeled "A" and "B" in Figure 2 do not show geometric similarity and hence reveal the Treatment X Posttest X Test Type interaction indicated in Table 3.

Since the graphs in Figure 2 indicate the performance superiority of the experimental group and since the experimental group's overall mean per cent correct (66.2%) was greater than the control group's overall mean per cent correct (43.4%), the significant Treatment main effect was interpreted to mean that the instructional procedures made a significant impact on the children's ability to serial order.

There was no significant Treatment X Posttest interaction. Therefore, the differences, if any, between the experimental and control groups' means (across test types) remained unchanged from posttest to posttest. Since the significant Treatment main effect indicated that differences likely existed in favor of the experimental group, the lack of a Treatment X Posttest interaction seemingly indicated that the experimental group's performance superiority remained relatively unchanged over the retention interval covered by the three posttests.

On the near transfer measures (across posttests) the experimental group's mean (80.2%) was 32.2 mean percentage points greater than the control group's mean (48.0). On the far transfer measures (across posttests) the experimental group's mean (52.3%) was only 13.6 mean percentage points greater than the control group's mean (38.7%). Thus, the significant Treatment X Test Type interaction could be interpreted to mean that the experimental group outperformed the control group on the near transfer tasks to a greater extent than it did on the far transfer tasks. It therefore appears that the Treatment main effect was mostly contributed by the treatment group differences in the performance of the near transfer measures.

The significant Test Type main effect was interpreted to mean that the overall mean for the near transfer measures (63.1%) was sig-

nificantly greater than the overall mean for the far transfer measures (45.1%). The absence of a significant Posttest X Test Type interaction seemingly suggested that time, as indicated by the posttest factor, did not alter the relative difficulty of the near and far transfer tasks.

No post hoc, multivariate procedures were available to examine the specific experimental-control differences which comprised the significant Treatment main effect. Consequently, the specific experimental-control group differences were analyzed through the use of two univariate, repeated measures analyses of variance for groups of unequal sizes (Winer, 1962, pp. 374-378). One univariate analysis was used with the near transfer data, and the other with the far transfer data.

For the use of univariate, repeated measures analysis it is suggested that percentage scores be transformed according to an arcsin function (Winer, 1962, p. 221) to scores measured in radians. The univariate repeated measures analyses were performed with both the percentage and the transformed data. With respect to the tests of significance, the analyses yielded the same results regardless of the kind of data used. Therefore, since percentage scores are more meaningful than scores given in terms of radians, the analysis of percentage data is reported here.

Table 4

Repeated Measures Analysis: Near Transfer
(Percentages)

Source of Variation	SS	df	MS	F
Between Subjects				
Treatment (A)	24771.56	1	24771.56	12.99**
Subjects w. groups	57171.88	30	1905.73	
Within Subjects				
Posttests (B)	408.39	2	204.19	0.40
A X B	2101.57	2	1050.78	2.09
B x Subjects w. groups	30339.27	60	505.65	

**$p < .01$

As Table 4 indicates, the univariate, repeated measures AVOVA of the near transfer data revealed a significant Treatment main effect (A) ($F = 12.99$, $df = 1/30$, $p < 0.01$) but neither a significant Posttest effect (B) ($F < 1.00$) nor a significant Treatment x Posttest (A x B) interaction ($F = 2.09$, $df = 2/60$, $p < 0.25$). The Treatment main effect was interpreted to mean that the experimental group's overall near transfer mean (80.2%) was significantly greater than the control group's overall near transfer mean (48.0).

The lack of a significant Treatment X Posttest interaction suggested that differences between the near transfer performances of the experimental and control groups remained unchanged across the posttest intervals. Therefore, since superior performance was shown by the experimental group as indicated by the graph of near transfer means (Figure 2) and the Treatment main effect, it was concluded that the experimental group's superiority in performing near transfer tasks remained unchanged over the posttest interval of approximately 132 days.

The results of the univariate, repeated measures analysis of far transfer data (see Table 5) revealed a Posttest main effect ($F = 3.9764$, $df = 2/60$, $p < 0.05$) but neither a Treatment main effect ($F = 2.3680$, $df = 1/30$, $p < 0.25$) nor a Treatment x Posttest interaction ($F = 2.7457$, $df = 2/60$, $p < 0.10$). Failure to find a significant treatment group difference on the far transfer tests leads to the conclusion that the training procedures lacked the necessary aspects to insure transfer of training to unfamiliar materials.

Table 5

Repeated Measures Analysis: Far Transfer
(Percentages)

Source of Variation	SS	df	MS	F
Between Subjects				
Treatment (A)	4354.82	1	4354.82	2.3680
Subjects w. groups	55169.94	30	1838.99	
Within Subjects				
Tests (B)	3963.70	2	1981.85	3.9764**
A X B	2736.96	2	1368.48	2.7457
B x Subject w. groups	29903.59	60	498.39	

** $p < .05$

Post hoc comparisons (Winer, 1962, pp. 377-378) associated with the observed far transfer Posttest main effect revealed that the far transfer mean (54.0%) for posttest 2 (across both treatment groups) was significantly greater than the far transfer mean (38.5%) for posttest 1 ($F = 7.7223$, df = $p < .01$) but not significantly greater than the far transfer mean (43.9%) for posttest 3 ($F = 3.2555$, df = 1/60, $p < .10$). No difference was found between the means for posttests 1 and 3 (F 1.0).

Experimental versus Control versus Special Control Group Analysis

For this part of the overall analysis, multivariate techniques were used to compare the performances of the experimental, control, and special control groups on the near, far, and far-far transfer measures of posttest 3.

The experimental and control group subjects were in seriation stage II (could order but not insert sticks) at the beginning of the experiment. The special control group subjects, on the other hand, were in seriation stage III (could both order and insert sticks) at the beginning of the experiment. Therefore, if the instruction, which was designed

to induce stage III capabilities in stage II children (experimental subjects), was successful, no differences should appear between the experimental and special control groups' performances of posttest 3 measures. Since the control group subjects were in stage II at the beginning of the experiment and were given no instruction, they would likely perform less well on posttest 3 than the stage III, special control subjects.

The analysis was necessarily performed in two parts. One part compared the performances of the experimental and special control groups while the other part compared the performances of the special control and control groups.

The results of the experimental versus special control group analysis revealed (Table 6) that the two groups did not differ in their performances of posttest 3 (Multivariate $F = 0.2795$, $df = 3/40$, $p < 0.8399$). Thus, approximately 132 days after instruction, the experimental group subjects, who began the study with serial ordering stage II capabilities, performed serial ordering tasks just as well as the special control group subjects who began the study with seriation stage III capabilities.

Table 6

Multivariate Analysis: Experimental (E) versus Special Control (SC) on the Three Measures of Posttest 3

Posttest 3 Measures	Means E(n=15)	Means SC(n=13)	df	Step-down F	p less than
Near Transfer	76.7%	88.5%	1,42	0.4670	0.4987
Far Transfer	46.7	46.2	1,42	0.0115	0.9151
Far-Far Transfer	30.0	51.9	1,42	0.3780	0.5422

The results of the special control versus control group analysis revealed that the groups differed in their performances of posttest 3 (Multivariate $F = 5.6897$, $df = 3/40$, $p < 0.0025$). The step-down F ratios (Table 7) showed that significant differences existed be-

tween the two groups' performances on the near and far-far transfer measures but no difference existed between their performances on the far transfer measures. The means shown in Table 7 indicate that where differences did exist, the special control group outperformed the control group.

Table 7

Multivariate Analysis: Special Control (SC) versus Control (C) on the Three Measures of Posttest 3

Posttest 3 Measures	Means SC(n=13)	C(n=17)	df	Step-down F	p less than
Near Transfer	88.5%	52.9%	1,42	6.2504	0.0165
Far Transfer	46.2	41.2	1,42	1.1109	0.2981
Far-Far Transfer	51.9	20.6	1,42	8.3658	0.0062

To summarize, the experimental subjects acquired and retained the specific target capabilities of the instruction. They did not acquire the ability to transfer those capabilities to serial ordering tasks requiring the use of unfamiliar materials. Nevertheless, approximately 132 days after instruction, the experimental subjects performed as well as subjects (special control) who had acquired the target capabilities prior to the study.

DISCUSSION

The instruction used in this study produced substantial, durable changes in children's abilities to perform specific serial ordering tasks. This finding seemingly supports the idea that the acquisition of serial ordering capabilities depends, in part, on learning and not solely on the unfolding of some internal developmental structure or mechanism. Furthermore, the relative success of the instruction implies that the American learning theory approach, characterized in this study by the emphasis on corrective feedback, attention to relevant task stimuli, cuing and cue fading, can provide a viable basis for the construction of instructional system designed to influence the child's acquisition of certain, specific cognitive abilities.

The lack of transfer effects seemed to indicate that the instruction did not produce a massive change in the child's general ability to deal with order. A variety of contentions can be made in response to the lack of transfer effects. For example, it might be contended that there was no change in the fundamental ability because the children already had the ability; they merely failed to reveal it because they could not identify the task relevant characteristics inherent in unfamiliar materials. A possible second contention is that the variety of instructional materials was not sufficient enough to provide the children with an adequate opportunity for acquiring the substantive elements of the ordering capabilities. Still a third contention, made from a Piagetian position, might be that substantial changes in the ability to order cannot be made through the use of specific, short-term instruction. Clearly more research is needed.

Coxford's (1964) study revealed that it was possible to induce conservation of serial and ordinal correspondence in children who, before training, could construct serial correspondence. Similarly, the results of the study reported here revealed that it was possible to induce specific seriation stage III capabilities (order and insert) in children who, before training, exhibited seriation stage II capabilities (order but not insert). Therefore,

contrary to Piaget's notion that cognitive capabilities cannot be substantially changed by specific training, the two serial ordering studies taken together provide support for the hypothesis that the ability to perform seriation tasks can be changed, at least to some extent, by relatively short periods of specific training. Conceivably then, the findings of this study set the stage for the future research which will probe into the effects of serial ordering instruction on subsequent science learning and intellectual development.

SYNOPSIS

Fifteen kindergarten children, who began the study with stage II seriation capabilities (i.e., could serial order sticks but could not insert a number of sticks into an already ordered set), were individually given 30 minutes of seriation training on three consecutive days. Cue fading and the manipulation of discrimination levels were used in the training to help the children meet successive performance criteria leading to the acquisition of stage III capabilities (i.e., both order objects and insert objects into an already ordered set). Posttests, each consisting of a near and far transfer measures, were given approximately one, eight, and 132 days after training. In general, the results revealed that the subjects acquired and retained the specific target capabilities of the training (near transfer measures), but failed to substantially transfer (far transfer measures) those acquired capabilities to the performance of seriation tasks involving unfamiliar materials.

BIBLIOGRAPHY

Bloom, B. S. Stability and change in human characteristics. New York: Wiley, 1964.

Bock, R. D. Multivariate analysis of variance of repeated measurements. In C. W. Harris (Ed.), Problems in measuring change. Madison, Wisconsin: The University of Wisconsin Press, 1963.

Coxford, A. F. The effects of instruction on the stage placement of children in Piaget's seriation experiments. The Arithmetic Teacher, 1964, 11, 4-9.

Elkind, D. Discrimination, seriation, and numeration of size and dimensional differences in young children: Piaget replication study VI. The Journal of Genetic Psychology, 1964, 104, 275-296.

Gelman, R. Conservation acquisition: A problem of learning to attend to relevant attributes. Journal of Experimental Child Psychology, 1969, 7, 167-187.

Goldschmidt, M. L. The role of experience in the acquisition of conservation, Proceedings, 76th Annual Convention of the American Psychological Association, 1968, 361-362.

Kingsley, R. C. & Hall, V. C. Training conservation through the use of learning sets. Child Development, 1967, 38, 1111-1126.

Kohlberg, L. Early education: A cognitive-developmental view. Child Development, 1968, 39, 1013-1062.

Piaget, J. The child's conception of number. New York: W. W. Norton, 1965. (Original English Publication: Humanities Press, 1952.)

Schafer, L. E. The effects of various materials on the young child's serial ordering capabilities. Unpublished study. Michigan State University, 1969.

Wallach, L., Wall, J., & Anderson, L. Number conservation: The roles of reversibility, addition-subtraction, and misleading perceptual cues. Child Development, 1967, 38, 425-442.

Winer, B. J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.